Oil and Gas Reserves Evaluation

"In the final analysis, the reliability of reserve estimates is a direct function of the available data and the competence and integrity of the estimator."

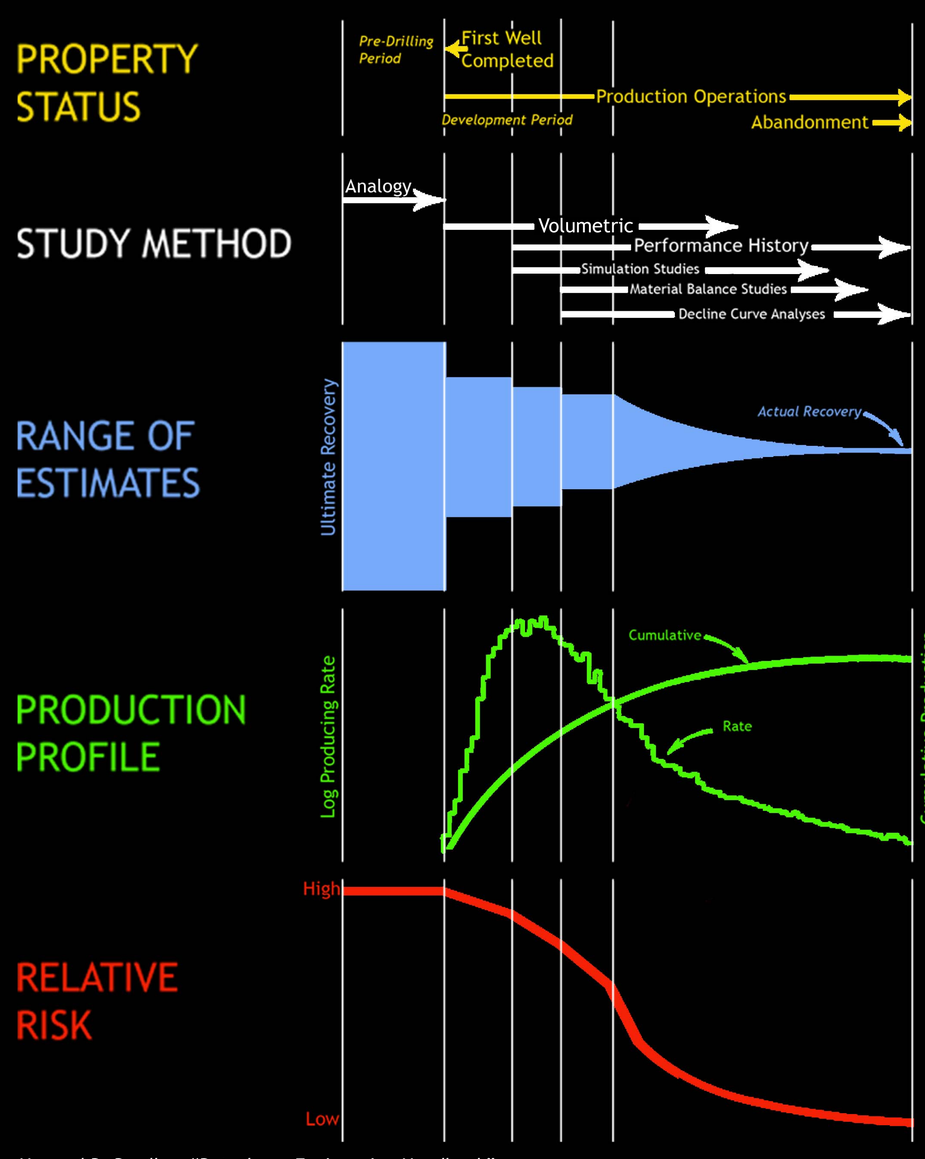
Society of Petroleum Evaluation Engineers, Monogram I, Second Edition,

Reserve Estimates

"Reserve" Synonymous with "Recoverable"

Oil and gas fields never give up all the oil and gas in a reservoir. Therefore, petroleum engineers make a distinction between "oil in p recoverable oil" is used in calculating the oil *reserves* of a field. The engineers who estimate reserves are called *reserves engineers*. The methods they use for estimating reserves are many and varied, and depend primarily upon the volume and quality of the available data.

"The meek shall inherit the Earth, but not its mineral rights."
J. Paul Getty



Howard B. Bradley, "Petroleum Engineering Handbook", Society of Petroleum Engineers, Texas, 1987.

Analogy Method

Pre-Drilling Period: After Field Discovery

Upon discovery of an oil field - in the *pre-drilling period* (see graph at left) - production data are scant at best. However, before a well is drilled, a calculation of a well's production potential on a barrel per acre-foot basis must be able to justify the costs of drilling the well. A simple method for hich performance of other wells or fields in the area is used to estimate the proposed well's potential production.

Volumetric Method

Development Defines Field Limits

As the new field is drilled - in the *de* becomes better-defined, the *volumetric* method is used to estimate reserves. Important subsurface data from driller's logs, well logs, and core samples taken from the wells are used by the geologists to define boundaries and to describe the type of reservoir trap. Petrophysicists interpret the well logs and core samples to identify the rock type and the substances in the pore spaces (for example, fresh water, salt water, gas, or oil), and to calculate the volume of pore space in the rock. All this information is then used by the reserves engineer to perform a volumetric estimate of the quantities of oil, gas, and water contained in the fiel er then applies a *recovery factor* (a multiplier based on the chosen method of operation or the drive mechanism of the field) to estimate the volume of oil that will be recoverable from the reservoir.

Decline Curve Analysis Method

Forecasting an Economic Limit

After production of a field has reac the reserves engineer employs statistical *performance history* methods, based on production and reservoir data accumulated during the field's development, to estimate remaining oil and gas reserves to an economic limit. In the decline curve analysis method, the well's cumulative production volume is plotted again r day, and a curve is interpolated. Extrapolation of this declining curve yields an estimate of total cumulative production that can be expected from the field.

Other Methods

Material Balance Calculations

Material balance calculations use reservoir pressure measurements to check estimates of *oil in place* and *gas in place*, and develop an understanding of the reservoir's drive mechanisms. Material balance equations rely on the assumption that as oil, gas, and water are produced from a reservoir there will be a corresponding change in reservoir pressure.

Numerical Simulation Modeling

A three-dimensional computer-based model may be employed to predict reservoir depletion. The *numerical simulation model* defines the reservoir geometry, spatial distribution of rock and fluid characteristics in the reservoir, and drive mechanism, and is calibrated to the actual reservoir production history. The model is run using a spectrum of operating options to determine optimum reservoir exploitation.

Elk Hills Changes Hands

Greatest Federal Privatization

On February 5, 1998, the largest divestiture of federal property in the history of the U.S. government was completed when the United States' interest in the Elk Hills Naval Petroleum Reserve was sold to Occidental Petroleum Corporation. The divestiture process began in 1995. The divestment took the federal government out of the oil and gas business at Elk Hills. Occidental Oil purchased the government's assets in 1998 for $3.65 billion which represented approximately 1.5 billion barrels of oil-equivalent (i.e., oil, gas, liquids).

Energy Secretary Federico Peña (left) and Occidental Petroleum's David Hentschel sign the historic transfer agreement with Patricia Godley, DOE's Assistant Secretary for Fossil Energy, who orchestrated the sale, looking on.

(photograph courtesy of U.S. Department of Energy, Office of Fossil Energy, www.fe.doe.gov)

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